This document contains the Draft EPA Report “Hull Coating Leachate Environmental Effects Analysis Report” published in August 2003.
The reference number is: EPA-842-D-06-003

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Environmental Effects Analysis Report
Hull Coating Leachate

August 2003

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ENVIRONMENTAL EFFECTS ANALYSIS REPORT:

HULL COATING LEACHATE

Prepared by:

Naval Sea Systems Command
U.S. Department of the Navy

Office of Water
U.S. Environmental Protection Agency

August 2003

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LIST OF ACRONYMS

BCC	Bioaccumulative Contaminants of Concern
ChAR	Characterization Analysis Report
EEA	Environmental Effects Analysis
EPA	Environmental Protection Agency
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
HI	Hazard Index
HQ	Hazard Quotient
MSDS	Material Safety Data Sheets
NAVSEA	Naval Sea Systems Command
NRL	Naval Research Laboratory
TBT	Tributyltin
TPE	Toxic Pound Equivalent
UNDS	Uniform National Discharge Standards
USCG	United States Coast Guard
VOC	Volatile Organic Compounds
WQC	Water Quality Criteria

1 Introduction

As determined by the *Phase II Uniform National Discharge Standards (UNDS) for the Vessels of the Armed Forces Environmental Effects Analysis Guidance* (EPA and Navy, 2000a, hereafter referred to as the *EEA Guidance Manual*), the *Environmental Effect Analysis Report: Hull Coating Leachate* presents information necessary to evaluate the regulatory options considered for the Hull Coating Leachate discharge. In UNDS Phase I, the Hull Coating Leachate discharge was determined to have potential adverse environmental effects largely because of the estimated amount of copper released from hull coatings; and therefore was considered for further action in the UNDS process (Navy and EPA, 1999).

A variety of underwater hull coating systems exist in the Armed Forces. Some vessels have no coating applied while others have complex coating systems consisting of a base anticorrosive coating and an antifouling coating topcoat. For the purpose of this discharge analysis, only vessels with coatings used to control fouling by marine organisms are studied (i.e., antifouling and foul-release coatings). Antifouling coatings typically contain biocides based on copper and zinc compounds that prevent growth of marine biofouling organisms (e.g., barnacles, tube-worms, algae, etc.) on hulls (EPA and Navy, 2003f). Foul-release coatings, typically based on silicone resins and oils, inhibit the adhesion of fouling organisms to the hull. Marine growth or fouling is undesirable because it increases drag, reduces speed, and increases fuel consumption.

The hull coating leachate discharge was characterized using coating manufacturer Material Safety Data Sheet (MSDS) information, release rate data collected by the United States (U.S.) Navy and coating manufacturers, and harbor data collected by the U.S. Navy. A description of the data collected, assumptions made, and calculations performed is presented in the *Characterization Analysis Report: Hull Coating Leachate* (Navy and EPA, 2003a, hereafter referred to as the *Hull Coating Leachate ChAR*).

In the *Nature of Discharge Report for the Hull Coating Leachate Discharge* (Navy and EPA, 1999, hereafter referred to as the *Nature of Discharge Report*), EPA and Navy estimated that approximately 160 small boats and craft of the Armed Forces were coated with tributyltin (TBT)-based paints in 1997. The small Armed Forces vessels assumed to have TBT-based coatings were on a three-to-five year recoating cycle; and therefore, all TBT-based coatings should have been replaced by 2003. Thus, it is assumed that vessels of the Armed Forces no longer use TBT-based coatings. Consequently, this environmental effects analysis makes the assumption that TBT-based coatings are not found on Armed Forces vessels.

1.1 Vessel Groups

Vessels that produce hull coating leachate were sorted into three vessel groups. The largest category is the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group, which encompasses most Armed Forces vessels. The USS NIMITZ (CVN 68) Class of aircraft carriers was selected as the vessel class on which to conduct analyses for this group. The second category is the Flexible Hulls (Non-Aluminum) vessel group, which is represented by the USS

LOS ANGELES (SSN 688) Class of submarines. The flexible hulls vessel group consists of vessels that have hulls covered with flexible elastomeric materials. The third category is the Aluminum Hulls vessel group, which includes numerous classes of smaller vessels used by the Armed Forces. Vessels with aluminum hulls include boats and craft ranging in length from less than 10 feet to 192 feet long. The USCG 47-foot Motor Lifeboat (MLB 47) was selected as the representative vessel class for this vessel group. Further information regarding the vessel groups and selection of representative vessel class is contained in the *Vessel Grouping and Representative Vessel Selection for Hull Coating Leachate Discharge* (EPA and Navy, 2003c).

1.2 Marine Pollution Control Device Options

After evaluating various technologies, three Marine Pollution Control Device (MPCDs) Option Groups:

- Establish a Maximum Allowable Copper Release Rate Standard for Antifouling Coatings,
- Foul-Release Coatings, and
- Advanced Antifouling Coatings

were determined to be feasible for further evaluation in the UNDS process. These MPCDs passed the MPCD screen as described in the *Marine Pollution Control Device Screen Criteria Guidance* (EPA and Navy, 2000b). A more detailed description of each MPCD Option Group is contained in the respectively named MPCD Screen documents (EPA and Navy, 2002a, 2003a and 2003b).

In addition to the MPCDs previously listed, the U.S. Navy has an active research program that continues to test and evaluate new coatings and coating technologies for future applications as they become commercially available.

1.3 Analysis Performed

The specific analyses to be performed are outlined in the *EEA Guidance Manual*. Seven tasks are to be completed for each option considered.

In Step 1, a comprehensive set of discharge characterization data and discharge parameters is assembled. Discharge characterization data include quantitative information (i.e., chemical constituent concentrations, temperature, pH, etc.) and qualitative information (i.e., color, odor, etc.). The source of these data for each discharge is the Characterization Analysis Report.

In Step 2, a variety of analyses are conducted on the discharge characterization data assembled to identify constituents of concern. Constituents are identified that exceed State and Federal numeric and narrative water quality criteria.

In Step 3, the toxicity of the discharge is evaluated by estimating acute marine aquatic-life toxicity at the edge of the 35m mixing zone, which is accomplished by calculating a Hazard

Index. The *EEA Guidance Manual* presents models used for estimating constituent concentrations at the edge of the mixing zone. For the Hull Coating Leachate Discharge, data around a hull was available and used in place of modeled data.

In Step 4, constituents identified are compared to the list of bioaccumulative contaminants of concern (BCCs) designated for elimination by various international, Federal, and State programs and those designated for reduction by U.S. permit and clean-up programs.

In Step 5, annual mass loadings are calculated for discharges occurring within 12 nm using the constituent concentrations and discharge volume. The mass loadings are used in conjunction with toxic weighting factors to calculate toxic pound equivalent (TPE) loadings.

In Step 6, an evaluation of the baseline discharge and MPCD options' potential to introduce nonindigenous species of plant and animal life into new environments is conducted. For the hull coating leachate discharge, qualitative discussions are presented for each option.

In addition to constituent analyses, other potential environmental impacts of the discharge are identified in Step 7. These impacts include any additional air releases, solid waste generation, or energy requirements of the options.

After completing these tasks, a summary of the results and ranking of MPCD options is presented along with a discussion of the uncertainty in the analyses.

2 Environmental Effects - Steel, Composite, and Other Non-Aluminum Rigid Hulls

Approximately 2,600 vessels are included in the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group, with a total wetted surface area of 2.4 x 10^7 ft^2. The vessel group accounts for 85% of vessels of all Armed Forces vessels that produce the hull coating leachate discharge and 91% of the total wetted hull surface area. The USS NIMITZ (CVN68) has been chosen as the vessel group on which to conduct analyses.

2.1 Baseline Discharge

The baseline discharge for this vessel group is the release of constituents from copper ablative coatings and vinyl antifouling coatings. The copper ablative coatings are widely used throughout the Navy, and vinyl antifouling coatings are used on a small number of barges and craft. The specific coating used on a vessel is determined locally at the time a coating is being applied. These coatings have an estimated 12-year service life on USS NIMITZ class vessels.

2.1.1 Characterization of Discharge

As described in the *Hull Coating Leachate ChAR*, approximately 86% of the hull surface area for the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group are coated with copper ablative coatings and 14% are coated with vinyl antifouling coatings. An average of constituent information for International Interspeed 640 (BRA640) and Ameron Coatings ABC #3 data was used to facilitate estimations for copper ablative coatings. Information on the constituents released from the copper ablative coatings and vinyl antifouling coatings is presented in Table 2-1. The concentrations at 1 cm from the hull are the values used for the end-of-pipe analyses.

Table 2-1. Constituents Released from the Copper Ablative Coatings and Vinyl Antifouling Coatings for the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

Constituent	Concentration at 1 cm from the Hull (µg/l)	Release Rate (µg/cm²/day)	
		Static	Dynamic
Copper Ablative Coatings			
Total Copper	5.3	8.9	17.0
Total Iron	0.26	0.44	0.84
N-ethyltoluenesulfonamide	0.31	0.52	1.2
Plasticizer	0.28	0.47	1.1
Polyamide resin	0.28	0.47	1.1
Rosin	1.0	1.6	3.8
Total Zinc	2.1	3.6	6.7
Vinyl Antifouling Coatings			
Total Copper	6.8	12	22
N-ethyltoluenesulfonamide	0.68	1.1	2.2
Rosin	2.2	3.7	6.9
Vinyl Chloride-Vinyl Acetate Copolymer	0.68	1.1	2.2

Note:
Static Release Rate = Release rate of a constituent when a vessel is stationary.
Dynamic Release Rate = Release rate of constituent when a vessel is underway.

A complete description of the information collected, assumptions made, and calculations performed to estimate the concentrations and release rates is contained in the *Hull Coating Leachate ChAR*.

2.1.2 Comparison to Water Quality Criteria

The comparison of the baseline discharge constituent data to the Federal and various State numeric water quality criteria (WQC) standards indicates that total copper is the only constituent with a concentration at 1 cm from the hull that exceeds any of the Federal and State WQC standards. As presented in Table 2-2, total copper discharge from vinyl antifouling coatings exceeds 20 of the 24 existing Federal and State acute numeric saltwater WQC and 17 of the 18 existing Federal and State chronic numeric saltwater WQC. The total copper discharge from the baseline copper ablative coatings exceeds 19 of the 24 existing Federal and State acute numeric saltwater WQC and 16 of the 18 existing Federal and State chronic numeric saltwater WQC. State numeric freshwater WQC are not exceeded by the baseline discharge.

Table 2-2. Constituents Exceeding Numeric Water Quality Criteria in the Baseline Discharge for the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

Constituents	Concentration at 1 cm from the Hull (µg/l)	No. of Criteria Exceeded	Strictest Criterion (µg/l)	State(s) with Strictest Criterion
Copper Ablative Coatings				
Total Copper	5.3	Acute: 19 of 24 Chronic: 16 of 18	2.4	MS, CT, GA
Vinyl Antifouling Coatings				
Total Copper	6.8	Acute: 20 of 24 Chronic: 17 of 18	2.4	MS, CT, GA

The baseline discharge is not expected to exceed any State narrative WQC categories (Navy and EPA, 2003a). Narrative criteria for odor and taste include the comparison of constituent concentrations to recommended Federal WQC for organoleptic effect (EPA, 1999; EPA and Navy, 2000a). Total copper and total zinc are both included in the list of organoleptic criteria constituents, but the recommended organoleptic WQC are 1000µg/l for total copper and 5000 µg/l for total zinc, which are at least two orders of magnitude higher than the corresponding baseline discharge concentrations at 1 cm from the hull. Therefore, the baseline discharge is not expected to exceed the odor and taste WQC. Appendix A provides the complete narrative WQC evaluation endpoints.

2.1.3 Discharge Toxicity

Due to seawater samples being collected at various distances around a hull coated with BRA640 and analyzed for copper), modeling of the baseline discharge was not required. Results from the analyses are presented in the *Hull Coating Leachate ChAR* as well as estimated constituent concentrations at the edge of the mixing zone. The results of the hazard index (HI) calculations are presented in Table 2-3. According to the *EEA Guidance Manual,* only constituents with a hazard quotient (HQ) greater than 1 at 1 cm from the hull (concentrations at 1 cm are considered to be the functional equivalent of end-of-pipe concentrations as described in the *EEA Guidance Manual*) are required to be included in the table. The potential for acute toxic effects to aquatic species is considered to be at an acceptable level when the Hazard Index is less than or equal to 1.0. More information on the use of HI calculations in the UNDS program is contained in *Method for Assessing the Toxicity of Multiple Contaminants in Discharges from Vessels of the Armed Forces Uniform National Discharge Standards (UNDS) Phase II* (Navy and EPA, 2001).

Table 2-3. Constituents of Concern with Hazard Quotient > 1 at 1 cm from the Hull in the Baseline Discharge for the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

Constituent of Concern	Hazard Quotient at 35 m Edge-of-Mixing Zone
Copper Ablative Coatings	
Total Copper	6.9×10^{-3}
HI of Above Constituents	6.9×10^{-3}
Total Discharge HI	7.0×10^{-3}
Vinyl Antifouling Coatings	
Total Copper	8.9×10^{-3}
HI of Above Constituents	8.9×10^{-3}
Total Discharge HI	8.9×10^{-3}

2.1.4 Release of Nonindigenous Species

Copper ablative coatings and vinyl antifouling coatings can reduce the potential for the release of nonindigenous species. The purpose of antifouling coatings is to prevent marine organisms from growing on the hull. By preventing growth of marine organisms, the transport of nonindigenous species is minimized. Thus, an effective antifouling coating helps to prevent the transport of such species. In addition, hull-cleaning procedures, when performed prior to leaving port, reduce the potential for Armed Forces vessels to serve as a vector for delivering species to ports, in which the species could be considered nonindigenous. The hull cleaning procedures also reduce the local micro-environment that could host foreign nonindigenous species on the return voyage to the United States.

2.1.5 Bioaccumulative Contaminants of Concern

The two constituents, total copper and total zinc, from the baseline discharge are identified as reduction bioaccumulative contaminants of concern (BCCs). BCCs for the UNDS program are divided into two types: 1) constituents designated for elimination by various international, Federal, and State programs, and 2) those designated for reduction by U.S. permit and cleanup programs. Table 2-4 presents the identified BCCs and concentration at 1 cm from the hull for the baseline discharge.

Table 2-4. BCCs Identified in the Baseline Discharge for the Steel, Composite, and Other Non-Aluminum Vessel Group

Elimination BCCs (µg/l)		Reduction BCCs (µg/l)	
Constituent	**Concentration at 1 cm from the Hull (µg/l)**	**Constituent**	**Concentration at 1 cm from the Hull (µg/l)**
Copper Ablative Coatings			
None		Total Copper	5.3
		Total Zinc	2.1
Vinyl Antifouling Coatings			
None		Total Copper	7.5

2.1.6 Constituent Mass Loadings and Toxic Pound Equivalents

Constituent mass loading and toxic pound equivalent (TPE) values are calculated for freshwater and saltwater operations based on the discharge generated for each vessel in this vessel group when operating within 12 nm and at pierside. Loadings are only calculated for active vessels homeported in the United States. Vessels less than 25′ in length are assumed to be removed from the water when pierside and do not generate any discharge during that period. Table 2-5 presents the mass loading and TPE information for the constituents identified in the baseline discharge for the active vessels in this vessel group.

Table 2-5 Mass and Toxic Pound Equivalent Loadings from the Baseline Discharge for the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

Discharge Constituent	Mass Loading (lb/yr)		Toxic Pound Equivalent Loading (lb-equiv/yr)	
	Saltwater	**Freshwater**	**Saltwater**	**Freshwater**
Total Copper	120,000	1800	220,000	1100
Total Zinc	39,000	590	2,700	27
Total Iron	4,800	73	8.2	0.41
Total	**160,000**	**2500**	**220,000**	**1200**

2.1.7 Other Potential Environmental Impacts

Volatile organic compounds (VOCs) are released and solid waste is generated during each coating application. Baseline discharge values are used as a comparison when discussing the other potential environmental impacts for the MPCD
options. Detailed calculations are presented in Appendix B. Other potential environmental impacts have not been identified for the baseline coating.

2.2 Establish a Maximum Allowable Copper Release Rate Standard for Antifouling Coatings

The MPCD to Establish a Maximum Allowable Copper Release Rate Standard for Antifouling Coatings may result in a reduction in the amount of copper released to the environment. This MPCD would use total copper release rates for the present copper ablative coatings to establish a maximum release rate for copper. Coatings would be tested in accordance with ASTM Standard Test Method D 6442, and coatings that exceed the maximum release rate would not be used on Armed Forces vessels. For the purposes of this analysis, no immediate change is anticipated; however, over time, establishment of a maximum copper release rate may result in reduction in environmental effects.

2.3 Foul-Release Coatings

The environmental effects of using foul-release coatings for the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group in place of copper ablative coatings are presented in the following sections. Foul-release coatings do not use copper or any other biocide to provide biofouling control. International Intersleek 425, is the only foul-release coating approved for use on Armed Forces vessels; this product is used as the basis for the analyses presented in this report.

2.3.1 Characterization of Discharge

The unique surface chemistry of foul-release coatings creates a surface to which fouling cannot easily adhere (NRL, 1997). The U.S. Environmental Protection Agency (EPA) has determined that foul-release coatings are exempt from reporting under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (Public Law 95-396), because biocides are not released to control biofouling. The release of any other constituents that may be present in Intersleek 425 is expected to be negligible. Therefore, toxic or hazardous constituents are assumed not to be released to the environment.

2.3.2 Comparison to Water Quality Criteria

Foul-release coatings are not designed to release biocides to control biofouling. Therefore, it is not expected that numeric WQC would be exceeded.

The discharge from foul-release coatings is not expected to exceed any State narrative WQC categories. Data is not available for any further analysis.

2.3.3 Discharge Toxicity

The release of constituents from and resulting discharge toxicity of foul-release coatings is expected to be negligible.

2.3.4 Release of Nonindigenous Species

Foul-release coatings are intended to produce a unique surface to which fouling organisms cannot easily adhere. The coatings rely on the movement of water across the hull surface to prevent attachment of organisms and to dislodge attached organisms. However, once a vessel is pierside, fouling organisms readily attach to the hull. The potential for transport and release of nonindigenous species is low for a continuously moving vessel with effective foul-release coatings, because organisms cannot easily adhere to foul-release coatings. However, the efficacy of a foul-release coating is dependent on vessel design details. Hull areas that are recessed, rough, or shielded from flow can accumulate fouling organisms that can be transported and released. Hull-cleaning procedures, when performed prior to leaving port, remove most organisms attached to the hull and reduce the potential for transfer and release of nonindigenous species from that port. However, current hull cleaning procedures have been demonstrated to damage the coating and degrade coating efficacy. In conclusion, foul-release coatings are not capable of preventing fouling on all hull areas, and the potential for transfer and release of nonindigenous species is greater than for the use of biocidal coatings.

2.3.5 Bioaccumulative Contaminants of Concern

Bioaccumulative contaminants of concern have not been identified in foul-release coatings.

2.3.6 Constituent Mass Loadings and Toxic Pound Equivalents

Foul-release coatings are not designed to release any biocides to the marine environment. The release rates of any other constituents from International Intersleek 425 are estimated to be negligible. For the purpose of this analysis, mass loading and toxic pound equivalent values are assumed to be zero.

2.3.7 Other Potential Environmental Impacts

Foul-release coatings need to be reapplied more frequently than the baseline copper ablative coatings. For example, the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group can use copper ablative coatings to achieve a service life of up to 12 years. Foul-release coatings have demonstrated a maximum life of three years (USCG, 2000). Over a 12-year period, vessels coated with foul-release coatings are estimated to require a minimum of four coating applications. The increased number of coating applications would result in additional volatile organic compound (VOC) emissions and solid waste generation. The additional applications result in approximately 1,300 pounds of VOCs released and 3.4×10^5 pounds of solid waste generated for a USS NIMITZ class vessel on an annual basis. The complete calculations are included in Appendix B.

2.4 Advanced Antifouling Coatings

The environmental effects of using advanced antifouling coatings for the Steel, Composite, and Non-Aluminum Rigid Hull vessel group in place of copper ablative coatings are presented in the following sections. The advanced antifouling coating, *E Paint SN-1*, is the only paint of this type approved for use on select Armed Forces vessels and the basis for the subsequent analyses.

2.4.1 Characterization of Discharge

Information on the constituents released from *E Paint SN-1* is presented in Table 2-6. The concentrations at 1 cm from the hull are the values used for the end-of-pipe analyses.

Table 2-6. Constituents Released from Advanced Antifouling Coatings for the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

Constituent	Concentration at 1 cm from the Hull (μg/l)	Release Rate (μg/cm²/day)
4,5-dichloro-2-n-octyl-4-isothaizolin-3-one	1.0	1.8
Total Zinc	10	17

A complete description of the information collected, assumptions made, and calculations performed to estimate concentrations and release rates is contained in the *Hull Coating Leachate ChAR*.

2.4.2 Comparison to Water Quality Criteria

The comparison of the advanced antifouling coating constituents' concentrations at 1 cm from the hull to numeric WQC indicates that none of the constituents released exceed any Federal or

State numeric acute or chronic WQC. The advanced antifouling coating constituent, Sea-Nine 211® (4,5-dichloro-2-n-octyl-4-isothiazolin-3-one), has not been included in any Federal or State saltwater or freshwater numeric WQC standards.

The discharge from advanced antifouling coatings is not expected to exceed any State narrative WQC categories (Navy and EPA, 2003a). Data is not available for any further analysis.

2.4.3 Discharge Toxicity

With a toxicological endpoint concentration of 1.3µg/l for 4,5-dichloro-2-n-octyl-4-isothiazolin-3-one (Shaner, 2003), the Hazard Quotient at 1 cm from the hull is 0.80. The Hazard Quotient at the 1 cm from the hull for Total Zinc is 0.11. Therefore, the Hazard Quotient value at 1 cm from the hull did not exceed 1.0 for any constituent released. As described in the *Hull Coating Leachate ChAR*, the concentration of 4,5-dichloro-2-n-octyl-4-isothiazolin-3-one at the 35m edge of the mixing zone is estimated to be 6.5×10^{-3} µg/l and the Total Zinc concentration is estimated to be 6.3×10^{-2} µg/l. The Hazard Index value at the edge of the mixing zone is 5.7×10^{-3}.

The potential for acute toxic effects to aquatic species is considered to be at an acceptable level when the Hazard Index is less than or equal to 1.0. Additional information on the use of HI calculations in the UNDS program is contained in *Method for Assessing the Toxicity of Multiple Contaminants in Discharges from Vessels of the Armed Forces Uniform National Discharge Standards (UNDS) Phase II* (Navy and EPA, 2001).

2.4.4 Release of Nonindigenous Species

The biocides in the currently approved, advanced antifouling coatings are not as effective at controlling fouling as copper biocides (Lawrence, 2003). This increases the probability that fouling organisms survive the transit between ports, thus increasing the likelihood of releasing nonindigenous species. Hull-cleaning procedures, if performed prior to leaving port, would remove most organisms attached to the hull and reduce the potential for transfer and release of nonindigenous species from that port.

2.4.5 Bioaccumulative Contaminants of Concern

Total zinc is the only constituent for the advanced antifouling coating discharge that was identified as a reduction bioaccumulative contaminant of concern (BCC). BCCs for the UNDS program are divided into two types: 1) constituents designated for elimination by various international, Federal, and State programs, and 2) those designated for reduction by U.S. permit and cleanup programs. Table 2-7 presents the identified BCC and concentration at 1 cm from the hull for the advanced antifouling coating discharge.

Table 2-7. BCCs Identified in the Advanced Antifouling Coating Discharge for the Steel, Composite, and Other Non-Aluminum Vessel Group

Elimination BCCs		Reduction BCCs	
Constituent	**Concentration at 1 cm from the Hull (µg/l)**	**Constituent**	**Concentration at 1 cm from the Hull (µg/l)**
None		Total Zinc	10

2.4.6 Constituent Mass Loadings and Toxic Pound Equivalents

Constituent mass loading and TPE values are calculated for freshwater and saltwater operations based on the discharge generation volume for every vessel in this vessel group when operating within 12 nm and at pierside. Loadings are only calculated for active vessels homeported in the United States. Vessels less than 25′ in length are assumed to be removed from the water when pierside and do not generate any discharge during that period. Table 2-8 presents the mass loading and TPE information for the constituents released from advanced antifouling coatings for the active vessels in this vessel group.

Table 2-8 Mass and Toxic Pound Equivalent Loadings for Advanced Antifouling Coatings for the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

Discharge Constituent	Mass Loading (lb/yr)		Toxic Pound Equivalent Loading (lb-equiv/yr)	
	Saltwater	**Freshwater**	**Saltwater**	**Freshwater**
4,5-dichloro-2-n-octyl-4-isothiazolin-3-one	21,000	250	430,000	5,300
Total Zinc	200,000	2,400	13,000	110
Total	220,000	2,600	450,000	5,400

2.4.7 Other Potential Environmental Impacts

Advanced antifouling coatings of the type currently approved for use on Armed Forces vessels do not have the same life expectancy as existing copper-containing coatings. Therefore, they must be removed and reapplied more frequently than the baseline copper ablative coatings. For the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group, copper ablative coatings (i.e., qualified to MIL-PRF-24647) have a service life of up to 12 years. Although the Navy has a program to identify an advanced antifouling coating that will perform effectively for 12-years, the currently approved, advanced antifouling coatings have a maximum life of 2 years (USCG, 2000). The increased painting frequency results in additional VOC emissions and solid waste generation. Over a 12-year period, vessels are estimated to require five additional applications of foul-release coatings when compared to copper ablative coatings. The hypothetical additional applications[1] would result in approximately 5,800 pounds of VOCs released and 5.6×10^5 pounds of solid waste generated for a USS NIMITZ class vessel on an annual basis. The complete calculations are included in Appendix B.

[1] The applications are hypothetical because *E Paint SN-1* is not approved for use on any Navy vessel.

3 Environmental Effects - Flexible (Non-Aluminum) Hulls

The Flexible (Non-Aluminum) Hulls vessel group includes approximately 59 vessels and accounts for 1.9% of vessels and 8.4% of the wetted hull surface area in the hull coating leachate discharge. The USS LOS ANGELES was chosen as the representative vessel group.

At present, these vessels use the same coatings as the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group. Navy research continues to search for coatings that may be more suitable to the flexible exterior of these vessels.

3.1 Baseline Discharge

The baseline discharge for the Flexible Hulls vessel group is the release of constituents from standard copper ablative coatings, such as International Interspeed 640 (BRA640) and Ameron Coatings ABC #3. These coatings are widely used throughout the Navy. The specific coating used on a vessel is determined locally at the time a coating is being applied. These coatings typically have a service life of three to five years on a flexible hull vessel as compared to the 12 year service life on a steel hulled vessel. The difference in estimated service life between vessel groups is due to the thickness of the copper ablative coating that is applied to each vessel group. Vessels with flexible hulls use a thinner coating system than vessels with rigid hulls; because these vessels are docked more frequently allowing more opportunities for recoating the antifouling, and a thinner coating is less prone to cracking on the flexible exterior or these vessels.

3.1.1 Characterization of Discharge

As described in the *Hull Coating Leachate ChAR*, an average of the constituent data for International Interspeed 640 (BRA640) and Ameron Coatings ABC #3 was chosen as the baseline coating for this vessel group to facilitate estimations. Information on the constituents released from the baseline coating is presented in Table 3-1. The concentrations at 1 cm from the hull are the values used for the end-of-pipe analyses and are based on the data used in the steel, composite, and other non-aluminum rigid hulls category.

Table 3-1. Constituents Released from the Baseline Coating for the Flexible (Non-Aluminum) Hulls Vessel Group

Constituent	Concentration at 1 cm from the Hull (µg/l)	Release Rates (µg/cm²/day)	
		Static	Dynamic
Total Copper	5.3	8.9	17
Total Iron	0.26	0.44	0.84
N-ethyltoluenesulfonamide	0.31	0.52	1.2
Plasticizer	0.28	0.47	1.1
Polyamide resin	0.28	0.47	1.1
Rosin	1.0	1.6	3.8
Total Zinc	2.1	3.6	6.7

A complete description of the information collected, assumptions made, and calculations performed to predict concentrations and release rates is contained in the *Hull Coating Leachate ChAR*.

3.1.2 Comparison to Water Quality Criteria

The comparison of the baseline discharge constituent data to the Federal and various State WQC standards indicates that total copper is the only constituent with a concentration at 1 cm from the hull that exceeds any of the Federal and State WQC standards. As presented in Table 3-2, total copper discharge from the baseline coating exceeds 19 of the 24 existing Federal and State acute numeric saltwater WQC and 16 of the 18 existing Federal and State chronic numeric saltwater WQC. State numeric freshwater WQC are not exceeded by the baseline discharge.

Table 3-2. Constituents Exceeding Numeric Water Quality Criteria in the Baseline Discharge for the Flexible (Non-Aluminum) Hulls Vessel Group

Constituents	Concentration at 1 cm from the Hull (µg/l)	No. of Criteria Exceeded	Strictest Criterion (µg/l)	State(s) with Strictest Criterion
Total Copper	5.3	Acute: 19 of 24 Chronic: 16 of 18	2.4	MS, CT, GA

The baseline discharge is not expected to exceed any State narrative WQC categories because of the difficulty in discerning the hull coating leachate discharge from the surrounding seawater and the concentrations of the identified constituents. Narrative criteria for odor and taste include the comparison of constituent concentrations to recommended Federal WQC for organoleptic effect (EPA, 1999; EPA and Navy, 2000a). Total copper and total zinc are both included in the list of organoleptic criteria constituents, but the recommended organoleptic WQC are 1000µg/l for total copper and 5000 µg/l for total zinc, which are at least two orders of magnitude higher than the corresponding baseline discharge concentrations at 1 cm from the hull. Therefore, the baseline discharge is not expected to exceed the odor and taste WQC. Appendix A provides the complete narrative WQC evaluation endpoints.

3.1.3 Discharge Toxicity

Due to seawater samples being collected at various distances around a hull coated with BRA640 and analyzed for copper), modeling of the baseline discharge was not required. Results from the analyses are presented in the *Hull Coating Leachate ChAR* as well as estimated constituent concentrations at the edge of the mixing zone. The results of the hazard index (HI) calculations are presented in Table 3-3. According to the *EEA Guidance Manual,* only constituents with a hazard quotient (HQ) greater than 1 at 1 cm from the hull (concentrations at 1 cm are considered to be the functional equivalent of end-of-pipe concentrations as described in the *EEA Guidance Manual*) are required to be included in the table. The potential for acute toxic effects to aquatic species is considered to be at an acceptable level when the Hazard Index is less than or equal to 1.0. More information on the use of HI calculations in the UNDS program is contained in *Method for Assessing the Toxicity of Multiple Contaminants in Discharges from Vessels of the Armed Forces Uniform National Discharge Standards (UNDS) Phase II* (Navy and EPA, 2001).

Table 3-3. Constituents of Concern with Hazard Quotient > 1 at 1 cm from the Hull in the Baseline Discharge for the Flexible (Non-Aluminum) Hulls Vessel Group

Constituent of Concern	Hazard Quotient at 35m Edge-of-Mixing Zone (35m)
Total Copper	6.9×10^{-3}
HI of Above Constituents	6.9×10^{-3}
Total Discharge HI	7.0×10^{-3}

3.1.4 Release of Nonindigenous Species

Copper ablative coatings can reduce the potential for the release of nonindigenous species. The purpose of antifouling coatings is to prevent marine organisms from growing on the hull. By preventing growth of marine organisms, the transport of nonindigenous species is minimized. Thus, an effective antifouling coating helps to prevent the transport of such species. In addition, hull-cleaning procedures, when performed prior to leaving port, reduce the potential for Armed Forces vessels to serve as a vector for delivering species to ports, in which the species could be considered nonindigenous. The hull cleaning procedures also reduce the local micro-environment that could host foreign nonindigenous species on the return voyage to the United States.

3.1.5 Bioaccumulative Contaminants of Concern

The two constituents, total copper and total zinc, from the baseline discharge identified as reduction BCCs are listed in Table 3-4.

Table 3-4. BCCs Identified in the Baseline Discharge for the Flexible Hull Vessel Group

Elimination BCCs		Reduction BCCs	
Constituent	Concentration at 1 cm from the Hull (µg/l)	Constituent	Concentration at 1 cm from the Hull (µg/l)
None		Total Copper	5.3
		Total Zinc	2.1

3.1.6 Constituent Mass Loadings and Toxic Pound Equivalents

Constituent mass loading and TPE values are calculated for saltwater operations based on the discharge generation volume for every vessel in this vessel group when operating within 12 nm and at pierside. Vessels in the Flexible Hulls category do not operate in freshwater. Loadings are only calculated for active vessels homeported in the United States. Vessels less than 25′ in length are assumed to be removed from the water when pierside and do not generate any discharge during that period. Table 3-5 presents the mass loading and TPE information for the constituents identified in the baseline discharge for the active vessels in this vessel group.

Table 3-5. Mass and Toxic Pound Equivalent Loadings from the Baseline Discharge for the Flexible Hulls Vessel Group

Discharge Constituent	Mass Loading (lb/yr)		Toxic Pound Equivalents (lb-equiv/yr)	
	Saltwater	Freshwater	Saltwater	Freshwater
Total Copper	7,600	0	14,000	0
Total Zinc	3,100	0	210	0
Total Iron	380	0	0.64	0
Total	11,000	0	14,000	0

3.1.7 Other Potential Environmental Impacts

VOCs are released and solid waste is generated during each coating application. Baseline discharge values are used as a comparison when discussing the other potential environmental impacts for the MPCD options. Detailed calculations are presented in Appendix B. Other potential environmental impacts have not been identified for the baseline coating.

3.2 Establish a Maximum Allowable Copper Release Rate Standard for Antifouling Coatings

The MPCD to Establish a Maximum Allowable Copper Release Standard for Antifouling Coatings may result in a reduction in the amount of copper released to the environment. This MPCD would use total copper release rates for the present copper ablative coatings to establish a maximum release rate for copper. Coatings would be tested in accordance with ASTM Standard Test Method D 6442, and coatings that exceed the maximum release rate would not be used on Armed Forces vessels. For the purposes of this analysis, no immediate change is anticipated; however, over time, establishment of a maximum copper release rate may result in reduction in environmental effects.

3.3 Foul-Release Coatings

As discussed in the *Hull Coating Leachate FIAR*, foul-release coatings were tested on an Australian submarine in the 1990s resulting in excessive hull fouling (DSTO, 1995; Holmdahl, 2000). Before foul-release coatings could be applied to U.S. Navy submarines, performance validation testing would be required on an existing Navy nuclear submarine to ensure that significant damage would not occur to critical shipboard systems. Validation testing has not been done. Therefore, the foul-release coatings MPCD option is not feasible for this vessel group, and no environmental effects analysis was conducted.

3.4 Advanced Antifouling Coatings

The advanced antifouling coating, *E Paint SN-1*, has not met the minimum performance requirements of military specification MIL-PRF-24647 and is not authorized for use on Navy vessels (Lawrence, 2003). Therefore, the Advanced Antifouling Coatings MPCD option is not feasible for this vessel group, which is entirely comprised of Navy vessels, and an environmental analysis is not conducted.

4 Environmental Effects - Aluminum Hulls

The Aluminum Hulls vessel group includes approximately 400 vessels and accounts for 13% of vessels of the Hull Coating Leachate discharge; but, only 0.46% of the wetted surface area due to the small size of these vessels. The USCG 47-foot Motor Lifeboat (MLB 47) is the representative vessel for this vessel group.

4.1 Baseline Discharge

For the Aluminum Hulls vessel group, foul-release or advanced antifouling coatings are currently used. The decision regarding which coating type to use is made by local maintenance staff based on issues such as the local rate of fouling growth, the prevalence of ice in a region, and the availability of contractors who can apply the foul-release coatings. The environmental effects analysis was completed with the estimate that 90% of hull wetted surface area are coated with advanced antifouling coatings and 10% are coated with foul-release coatings. This estimate is based on information from the USCG on the types of coatings currently applied on aluminum hulled vessels (Dust, 2003). As in previous sections, the coating, *E Paint SN-1*, is the basis for the advanced antifouling coating analyses and Intersleek 425 is the basis for the foul-release coating analyses.

4.1.1 Characterization of Discharge

For the baseline discharge, these quantities are used to estimate the constituent mass loading and TPE calculations. Concentrations at 1 cm from the hull and release rate data are not affected by the coating usage. As described in Section 2.3.1, release of constituents from foul-release coatings are expected to be negligible. Table 4-1 lists the constituents released from the advanced antifouling coating, *E Paint SN-1*.

Table 4-1. Constituents Released from Advanced Antifouling Coatings for the Aluminum Hulls Vessel Group

Constituent	Concentration at 1 cm from the Hull (µg/l)	Release Rate (µg/cm²/day)
4,5-dichloro-2-n-octyl-4-isothaizolin-3-one	1.0	1.8
Total Zinc	10	17

A complete description of the information collected, assumptions made, and calculations performed to estimate concentrations and release rates is contained in the *Hull Coating Leachate ChAR*.

4.1.2 Comparison to Water Quality Criteria

Foul-release coatings are not designed to release biocides to control biofouling, and the release of any other constituents is expected to be negligible. Therefore, it is not expected that numeric WQC would be exceeded.

The comparison of the advanced antifouling coating constituents' concentrations at 1 cm from the hull to numeric WQC indicates that none of the constituents released exceed any Federal or State numeric acute or chronic WQC. The advanced antifouling coating constituent, Sea-Nine 211® (4,5-dichloro-2-n-octyl-4-isothiazolin-3-one), has not been included in any Federal or State saltwater or freshwater numeric WQC standards.

The discharge from foul-release and advanced antifouling coatings is not expected to exceed any State narrative WQC categories (Navy and EPA, 2003a). Data is not available for any further analysis.

4.1.3 Discharge Toxicity

The release of constituents from and resulting discharge toxicity of foul-release coatings is expected to be negligible. Therefore, the hazard index at 35m assumed to be zero.

With a toxicological endpoint concentration of 1.3µg/l for 4,5-dichloro-2-n-octyl-4-isothiazolin-3-one (Shaner, 2003), the Hazard Quotient at 1 cm from the hull is 0.80. The Hazard Quotient at 1 cm from the hull for Total Zinc is 0.11. Therefore, the Hazard Quotient value at 1 cm from the hull did not exceed 1.0 for any constituent released. As described in the *Hull Coating Leachate ChAR*, the concentration of 4,5-dichloro-2-n-octyl-4-isothiazolin-3-one at the 35m edge of the mixing zone is estimated to be 5.0×10^{-3} µg/l and the Total Zinc concentration is estimated to be 6.3×10^{-2} µg/l. The Hazard Index value at the edge of the mixing zone is less than 1.0 and is not required to be presented in this environmental effects analysis report.

The potential for acute toxic effects to aquatic species is considered to be at an acceptable level when the Hazard Index is less than or equal to 1.0. Additional information on the use of HI calculations in the UNDS program is contained in *Method for Assessing the Toxicity of Multiple Contaminants in Discharges from Vessels of the Armed Forces Uniform National Discharge Standards (UNDS) Phase II* (Navy and EPA, 2001).

4.1.4 Release of Nonindigenous Species

For the Aluminum Hulls vessel group, most vessels are less than 55 feet long and do not travel far from their homeport. The potential for transfer and release of nonindigenous species is low, because the contact with such species is minimized.

For vessels that transit further distances, the performance of coatings that minimize fouling is important in determining the potential for release. As previously stated in Section 2.3.4, foul-release coatings are intended to produce a unique surface to which fouling organisms cannot easily adhere. The coatings rely on the movement of water across the hull surface to prevent attachment of organisms and to dislodge attached organisms. However, once a vessel is pierside, fouling organisms readily attach to the hull. The potential for transport and release of nonindigenous species is low for a continuously moving vessel with effective foul-release coatings, because organisms cannot easily adhere to foul-release coatings. However, the efficacy of a foul-release coating is dependent on vessel design details. Hull areas that are recessed, rough, or shielded from flow can accumulate fouling organisms that can be transported and released. Hull-cleaning procedures, when performed prior to leaving port, remove most organisms attached to the hull and reduce the potential for transfer and release of nonindigenous species from that port. However, current hull cleaning procedures have been demonstrated to damage the coating and degrade coating efficacy. In conclusion, foul-release coatings are not capable of preventing fouling on all hull areas, and the potential for transfer and release of nonindigenous species is greater than for the use of biocidal coatings.

As previously described in Section 2.4.4, the biocides in the currently approved, advanced antifouling coatings are not as effective at controlling fouling as copper biocides (Lawrence, 2003). This increases the probability that fouling organisms survive the transit between ports, thus increasing the likelihood of releasing nonindigenous species. Hull-cleaning procedures, if performed prior to leaving port, would remove most organisms attached to the hull and reduce the potential for transfer and release of nonindigenous species from that port.

4.1.5 Bioaccumulative Contaminants of Concern

Bioaccumulative contaminants of concern have not been identified in foul-release coatings.

The one constituent, total zinc, from the advanced antifouling coating discharge is identified as a reduction bioaccumulative contaminant of concern (BCC). BCCs for the UNDS program are divided into two types: 1) constituents designated for elimination by various international, Federal, and State programs, and 2) those designated for reduction by U.S. permit and cleanup programs. Table 4-2 presents the identified BCC and concentration for the advanced antifouling coating discharge at 1 cm from the hull.

Table 4-2. BCCs Identified in the Baseline Discharge for the Aluminum Hulls Vessel Group

Elimination BCCs		Reduction BCCs	
Constituent	**Concentration at 1 cm from the Hull (µg/l)**	**Constituent**	**Concentration at 1 cm from the Hull (µg/l)**
None		Total Zinc	10

4.1.6 Constituent Mass Loadings and Toxic Pound Equivalents

Constituent mass loading and toxic pound equivalent (TPE) values are calculated for freshwater and saltwater operations based on the discharge generation volume for every vessel in this vessel group when operating within 12 nm and at pierside. Loadings are only calculated for active vessels homeported in the United States. Vessels less than 25′ in length are assumed to be removed from the water when pierside and do not generate any discharge during that period. Table 4-3 presents the mass loading and TPE information for the constituents identified in the baseline discharge for the active vessels in this vessel group. The calculations are based on the estimate that 90% of the vessels in the vessel group are coated with advanced antifouling coatings and 10% are coated with foul-release coatings. Foul-release coatings are not designed to release any biocides to the marine environment. The release rates of any other constituents from International Intersleek 425 are estimated to be negligible. For the purpose of this analysis, mass loading and toxic pound equivalent values for foul-release coatings are assumed to be zero.

Table 4-3 Mass and Toxic Pound Equivalent Loadings from the Baseline Discharge for the Aluminum Hulls Vessel Group

Discharge Constituent	Mass Loading (lb/yr)		Toxic Pound Equivalents (lb-equiv/yr)	
	Saltwater	**Freshwater**	**Saltwater**	**Freshwater**
4,5-dichloro-2-n-octyl-4-isothaizolin-3-one	120	17	2,500	350
Total Zinc	1,100	150	77	7.0
Total	1,200	170	2,600	360

4.1.7 Other Potential Environmental Impacts

Volatile organic compounds (VOCs) are released and solid waste is generated during each coating application. Baseline discharge values are used as a comparison when discussing the other potential environmental impacts for the MPCD options. Detailed calculations are presented in Appendix B. Other potential environmental impacts have not been identified for the Aluminum Hulls vessel group.

4.2 Establish a Maximum Allowable Copper Release Rate Standard for Antifouling Coatings

The use of copper ablative coatings on aluminum vessels is not approved by the current specifications for underwater hull antifouling coatings due to the possibility of deposition corrosion (Navy, 2001; USCG, 2001). Therefore, the MPCD to Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings has been determined to not be feasible for this vessel group and an environmental analysis is not conducted.

4.3 Foul-Release Coatings

The environmental effects of using foul-release coatings for the Aluminum Hulls in the place of the current combination of foul-release and advanced antifouling coatings are presented in the following sections. Foul-release coatings are not designed to release any biocides to the marine environment. International Intersleek 425 is the only foul-release coating approved for use on Armed Forces vessels and the basis for all analyses.

4.3.1 Characterization of Discharge

The unique surface chemistry of foul-release coatings creates a surface to which fouling cannot easily adhere (NRL, 1997). The U.S. Environmental Protection Agency (EPA) has determined that foul-release coatings are exempt from reporting under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (Public Law 95-396), because biocides are not released to control biofouling. The release of any other constituents that may be present in Intersleek 425 is expected to be negligible. Therefore, toxic or hazardous constituents are assumed not to be released to the environment.

4.3.2 Comparison to Water Quality Criteria

Foul-release coatings are not designed to release biocides to control biofouling. Therefore, it is not expected that numeric WQC would be exceeded.

The discharge from foul-release coatings is not expected to exceed any State narrative WQC categories (Navy and EPA, 2003a). Data is not available for any further analysis.

4.3.3 Discharge Toxicity

The release of constituents from and resulting discharge toxicity of foul-release coatings is expected to be negligible.

4.3.4 Release of Nonindigenous Species

Foul-release coatings are intended to produce a unique surface to which fouling organisms cannot easily adhere. The coatings rely on the movement of water across the hull surface to prevent attachment of organisms and to dislodge attached organisms. However, once a vessel is pierside, fouling organisms readily attach to the hull. The potential for transport and release of nonindigenous species is low for a continuously moving vessel with effective foul-release coatings, because organisms cannot easily adhere to foul-release coatings. However, the efficacy of a foul-release coating is dependent on vessel design details. Hull areas that are recessed, rough, or shielded from flow can accumulate fouling organisms that can be transported and released. Hull-cleaning procedures, when performed prior to leaving port, remove most organisms attached to the hull and reduce the potential for transfer and release of nonindigenous species from that port. However, current hull cleaning procedures have been demonstrated to damage the coating and degrade coating efficacy. In conclusion, foul-release coatings are not capable of preventing fouling on all hull areas, and the potential for transfer and release of nonindigenous species is greater than for the use of biocidal coatings.

4.3.5 Bioaccumulative Contaminants of Concern

Bioaccumulative contaminants of concern have not been identified in foul-release coatings.

4.3.6 Constituent Mass Loadings and Toxic Pound Equivalents

Foul-release coatings are not designed to release any biocides to the marine environment. The release rates of any other constituents from International Intersleek 425 are estimated to be negligible. For the purpose of this analysis, mass loading and toxic pound equivalent values are assumed to be zero.

4.3.7 Other Potential Environmental Impacts

Foul-release coatings have a service life one year longer than advanced antifouling coatings, but, unlike advanced antifouling coatings, the existing coating would need to be removed prior to each application. The increased service life would reduce the frequency of coating application. The new coating application schedule would reduce the quantity of VOCs released by 11 pounds for a MLB 47 class vessel on an annual basis; but, the need to remove the coating prior to each application would increase the solid waste generated by 560 pounds on an annual basis. Other environmental impacts have not been identified.

4.4 Advanced Antifouling Coatings

The environmental effects of using advanced antifouling coatings for the Aluminum Hull vessel group in place of the current foul-release and advanced antifouling coating mixture is presented in the following sections. The advanced antifouling coating, *E Paint SN-1*, is the only coating of this type approved for use on select Armed Forces vessels and the basis for the following analyses.

4.4.1 Characterization of Discharge

Information on the constituents released from *E Paint SN-1* is presented in Table 4-4. The concentrations at 1 cm from the hull are the values used for the end-of-pipe analyses. As presented in the *Hull Coating Leachate ChAR*, the only constituent released from *E Paint SN-1* is Sea-Nine 211® (4,5-dichloro-2-n-octyl-4-isothaizolin-3-one).

Table 4-4. Constituents Released from Advanced Antifouling Coatings for the Flexible Hulls Vessel Group

Constituent	Concentration at 1 cm from the Hull (µg/l)	Release Rate (µg/cm²/day)
4,5-dichloro-2-n-octyl-4-isothaizolin-3-one	1.0	1.8
Total Zinc	10	17

A complete description of the information collected, assumptions made, and calculations performed to estimate concentrations and release rates is contained in the *Hull Coating Leachate ChAR*.

4.4.2 Comparison to Water Quality Criteria

The comparison of the advanced antifouling coating constituent concentrations at 1 cm from the hull to numeric WQC indicates that none of the constituents released exceed any Federal or State numeric acute or chronic WQC. The advanced antifouling coating constituent, Sea-Nine 211® (4,5-dichloro-2-n-octyl-4-isothiazolin-3-one), has not been included in any Federal or State saltwater or freshwater numeric WQC standards.

The discharge from advanced antifouling coatings is not expected to exceed any State narrative WQC categories (Navy and EPA, 2003a). Data is not available for any further analysis.

4.4.3 Discharge Toxicity

With a toxicological endpoint concentration of 1.3µg/l for 4,5-dichloro-2-n-octyl-4-isothiazolin-3-one (Shaner, 2003), the Hazard Quotient at 1 cm from the hull is 0.80. The Hazard Quotient at 1 cm from the hull for Total Zinc is 0.11. Therefore, the Hazard Quotient value at 1 cm from the hull did not exceed 1.0 for any constituent released. As described in the *Hull Coating Leachate ChAR*, the concentration of 4,5-dichloro-2-n-octyl-4-isothiazolin-3-one at the 35m edge of the mixing zone is estimated to be 6.5×10^{-3} µg/l and the Total Zinc concentration is estimated to be 6.3×10^{-2} µg/l. The Hazard Index value at the edge of the mixing zone is 5.7×10^{-3}.

The potential for acute toxic effects to aquatic species is considered to be at an acceptable level when the Hazard Index is less than or equal to 1.0. Additional information on the use of HI calculations in the UNDS program is contained in *Method for Assessing the Toxicity of Multiple Contaminants in Discharges from Vessels of the Armed Forces Uniform National Discharge Standards (UNDS) Phase II* (Navy and EPA, 2001).

4.4.4 Release of Nonindigenous Species

The biocides in the currently approved, advanced antifouling coatings are not as effective at controlling fouling as copper biocides (Lawrence, 2003). This increases the probability that fouling organisms survive the transit between ports, thus increasing the likelihood of releasing nonindigenous species. Hull-cleaning procedures, if performed prior to leaving port, would remove most organisms attached to the hull and reduce the potential for transfer and release of nonindigenous species from that port.

4.4.5 Bioaccumulative Contaminants of Concern

The one constituent, total zinc, from the advanced antifouling coating discharge is identified as a reduction bioaccumulative contaminant of concern (BCC). BCCs for the UNDS program are divided into two types: 1) constituents designated for elimination by various international, Federal, and State programs, and 2) those designated for reduction by U.S. permit and cleanup programs. Table 4-5 presents the identified BCC and concentration at 1 cm from the hull for the advanced antifouling coating discharge.

Table 4-5. BCCs Identified in the Advanced Antifouling Coating Discharge for the Aluminum Hulls Vessel Group

Elimination BCCs		Reduction BCCs	
Constituent	**Concentration at 1 cm from the Hull (µg/l)**	**Constituent**	**Concentration at 1 cm from the Hull (µg/l)**
None		Total Zinc	10

4.4.6 Constituent Mass Loadings and Toxic Pound Equivalents

Constituent mass loading and TPE values are calculated for saltwater and freshwater operations based on the discharge generation volume for every vessel in this vessel group when operating within 12 nm and at pierside. Loadings are only calculated for active vessels homeported in the United States. Vessels less than 25′ in length are assumed to be removed from the water when pierside and do not generate any discharge during that period. Table 4-6 presents the mass loading and TPE information for the constituents released from advanced antifouling coatings for the active vessels in this vessel group.

Table 4-6 Mass and Toxic Pound Equivalent Loadings from Advanced Antifouling Coatings for the Aluminum Hulls Vessel Group

Discharge Constituent	Mass Loading (lb/yr)		Toxic Pound Equivalents (lb-equiv/yr)	
	Saltwater	**Freshwater**	**Saltwater**	**Freshwater**
4,5-dichloro-2-n-octyl-4-isothaizolin-3-one	130	19	2,800	390
Total Zinc	1,200	170	85	7.7
Total	1,400	180	2,900	400

4.4.7 Other Potential Environmental Impacts

The currently approved, advanced antifouling coatings have a service life one year shorter than foul-release coatings on vessels in the Aluminum Hulls category. The decreased service life would increase the frequency of coating application, but existing coatings do not need to be removed for each application. As described in the *Feasibility Impact Analysis Report: Hull Coating Leachate* (Navy and EPA, 2003b), the existing coating would need to be top-coated every two years and removed every six years. The new coating application schedule would increase the quantity of VOCs released by 1.1 pounds for a MLB 47 class vessel on an annual basis, but the decreased need for coating removal would reduce the quantity of solid waste generated by 62 pounds on an annual basis. Other environmental impacts have not been identified.

5 Summation of Analyses

The analyses and ranking of MPCD options that passed the MPCD screen and were determined to be feasible in the *Feasibility Impact Analysis Report: Hull Coating Leachate* (Navy and EPA, 2003b) are presented in the following sections.

The MPCD options for hull coating leachate are:

- Establish a Maximum Allowable Copper Release Rate Standard for Antifouling Coatings,
- Foul-Release Coatings, and
- Advanced Antifouling Coatings.

The environmental effects are presented separately for each of the vessel groups: Steel, Composite, and Other Non-Aluminum Rigid Hulls; Flexible (Non-Aluminum) Hulls; and Aluminum Hulls.

As described in the *Hull Coating Leachate ChAR* (Navy and EPA, 2003a), variability in the composition of hull coating leachate occurs due to the wide range of coating constituent concentrations, the location of vessels, and the difficulty in measuring the release rate of constituents. Manufacturers' information and U.S. Navy studies are the sources of data for this analysis. Some manufacturer information (e.g., material safety data sheets, pesticide registration data, etc.) only includes data that is required by law to report. U.S. Navy studies focus on a limited number of constituents and data sets. All of these issues contribute to the uncertainty of the data and resulting analyses.

5.1 Summary of Results

A summary of the environmental effects analysis results for each vessel group are presented in the following sections.

5.1.1 Comparison to Water Quality Criteria

Constituent concentrations that exceeded the various Federal and State numeric acute and chronic WQC standards are presented in Table 5-1. The table lists the strictest WQC value exceeded.

Table 5-1. Comparison of Discharge Constituent Concentrations (µg/l) that Exceed Numeric Water Quality Criteria (WQC) for the Hull Coating Leachate Discharge

Discharge Constituent	Strictest WQC (µg/l)	Baseline Discharge	Establish Maximum Copper Standard	Foul-Release Coatings	Advanced Antifouling Coatings
		Concentration at 1 cm from the Hull (µg/l)			
Saltwater:					
Steel, Composite, and Other Non-Aluminum Rigid Hulls					
Total Copper	2.4 CT, GA, & MS: acute & chronic criteria	**Copper Ablative Coatings:** 5.3 **Vinyl Antifouling Coatings:** 6.8	**Copper Ablative Coatings:** 5.3 **Vinyl Antifouling Coatings:** 6.8	NA	NA
Flexible (Non-Aluminum) Hulls					
Total Copper	2.4 CT, GA, & MS: acute & chronic criteria	**Copper Ablative Coatings:** 5.3 **Vinyl antifouling coatings are not used on flexible hulled vessels.**	**Copper Ablative Coatings:** 5.3 **Vinyl antifouling coatings are not used on flexible hulled vessels.**	NF	NF
Aluminum Hulls					
None			NF		
Freshwater:					
Steel, Composite, and Other Non-Aluminum Rigid Hulls					
None					
Flexible (Non-Aluminum) Hulls					
None					NF
Aluminum Hulls					
None			NF		

NA = Not applicable; NF = MPCD option is not feasible.

Discharges from any of the MPCD options are not expected to exceed any State narrative WQC categories because of the difficulty in discerning the hull coating leachate discharge from the surrounding seawater and the concentrations of the identified constituents.

MPCD ranking by comparison to water quality criteria is:

1. Foul-Release Coatings
2. Advanced Antifouling Coatings
3. Establish a Maximum Allowable Copper Release Rate Standard for Antifouling Coatings.

5.1.2 Discharge Toxicity

Based on samples collected at varying distances from a vessel hull, the constituent concentrations for copper ablative and advanced antifouling coatings at the 35m edge of mixing zone were estimated. The results from Hazard Index calculations for MPCD options are presented in Table 5-2.

Table 5-2. Comparison of Hazard Index for MPCD Options of the Hull Coating Leachate Discharge

Vessel Group	Hazard Index at 35m Edge-of-Mixing Zone			
	Baseline Discharge	**Establish Maximum Copper Standard**	**Foul-Release Coatings**	**Advanced Antifouling Coatings**
Steel, Composite, and Other Non-Aluminum Rigid Hulls	Copper Ablative Coatings: $7.0x10^{-3}$ Vinyl Antifouling Coatings: $8.9x10^{-3}$	Copper Ablative Coatings: $7.0x10^{-3}$ Vinyl Antifouling Coatings: $8.9x10^{-3}$	0	$5.7x10^{-3}$
Flexible (Non-Aluminum) Hulls	$7.0x10^{-3}$	$7.0x10^{-3}$	NF	NF
Aluminum Hulls	$5.7x10^{-3}$	NF	0	$5.7x10^{-3}$

NF = MPCD option is not feasible.

MPCD ranking by discharge toxicity is:

1. Foul-Release Coatings
2. Advanced Antifouling Coatings
3. Establish a Maximum Allowable Copper Release Rate Standard for Antifouling Coatings.

5.1.3 Release of Nonindigenous Species

The purpose of an antifouling coating is to prevent marine organisms from growing on the hull. By preventing growth of marine organisms, the transport of nonindigenous species is minimized. At present, copper-ablative coatings are more effective at controlling fouling than advanced antifouling coatings. Foul-release coatings do not prevent fouling, but create a surface to which fouling organisms cannot easily adhere. The foul-release surfaces remain free of fouling provided a vessel is moving at moderate speeds (i.e., in excess of 15 knots) most of the time and the coating remains undamaged.

MPCD ranking by potential to release nonindigenous species is:

1. Establish a Maximum Allowable Copper Release Rate Standard for Antifouling Coatings.
2. Advanced Antifouling Coatings
3. Foul-Release Coatings

5.1.4 Bioaccumulative Contaminants of Concern

A comparison of the number of constituents identified as "elimination-BCCs" and "reduction-BCCs" among MPCDs is provided in Table 5-3.

Table 5-3 Bioaccumulative Contaminants of Concern Identified in Baseline and MPCD Discharges for the Hull Coating Leachate Discharge

BCCs	Baseline Discharge	Establish Maximum Copper Standard	Foul-Release Coatings	Advanced Antifouling Coatings
Steel, Composite, and Other Non-Aluminum Rigid Hulls				
Elimination	0	0	0	0
Reduction	2	2	0	1
Total	**2**	**2**	**0**	**1**
Flexible (Non-Aluminum) Hulls				
Elimination	0	0	0	NF
Reduction	2	2	0	NF
Total	**2**	**2**	**0**	NF
Aluminum Hulls				
Elimination	0	NF	0	0
Reduction	1	NF	0	1
Total	**1**	NF	**0**	**1**

NF = MPCD option is not feasible

The MPCD ranking by presence of BCCs for all vessel groups is:

1. Foul-Release Coatings
2. Advanced Antifouling Coatings
3. Establish a Maximum Allowable Copper Release Rate Standard for Antifouling Coatings.

5.1.5 Constituent Mass Loadings and Toxic Pound Equivalents

Mass and TPE loadings were calculated for each discharge constituent. Both the mass loading and TPE calculations are functions of the constituent concentrations and annual discharge volumes. Loadings were only calculated for active vessels homeported in the United States. Vessels less than 25′ in length were assumed to be removed from the water when pierside and did not generate any discharge during that period.

Mass loading data and TPE for baseline discharges and MPCD options are summarized in Table 5-4. Approximately 130,000 pounds per year of total copper are estimated to be discharge as a result of the Hull Coating Leachate discharge. In UNDS Phase I, the total annual loading of copper was estimated at 220,000 pounds (Navy and EPA, 1999). The present calculations resulted in a lower discharge quantity, because dynamic and static release rates and updated vessel information (e.g., wetted surface area with coatings applied, days in port, etc.) were used.

Table 5-4. Mass Loading and TPE for Baseline and MPCD Option Discharges for the Hull Coating Leachate Discharge

Discharge Constituent	Mass Loading (lb/yr)				Toxic Pound Equivalents (lb-equiv/yr)			
	Baseline Discharge	Maximum Copper Standard	Foul-Release Coatings	Advanced Antifouling Coatings	Baseline Discharge	Maximum Copper Standard	Foul-Release Coatings	Advanced Antifouling Coatings
Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group								
Total Copper			0		220,000	220,000	0	0
Total Zinc			0		2,700	2,700	0	14,000
Total Iron			0		8.6	8.6	0	0
4,5-dichloro-2-n-octyl-4-isothaizolin-3-one			0		0	0	0	440,000
Total			**0**		**220,000**	**220,000**	**0**	**450,000**
Flexible Hulls Vessel Group								
Total Copper	14,000	14,000	**NF**	**NF**	14,000	14,000	**NF**	**NF**
Total Zinc	210	210			210	210		
Total Iron	0.64	0.64			0.64	0.64		
Total	**14,000**	**14,000**			**14,000**	**14,000**		
Aluminum Hulls Vessel Group								
Total Zinc	84	**NF**	0	93	84	**NF**	0	93
4,5-dichloro-2-n-octyl-4-isothaizolin-3-one	2,900		0	3,200	2,900		0	3,200
Total	**3,000**		**0**	**3,300**	**3,000**		**0**	**3,300**

NF = MPCD option is not feasible.

For the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group, MPCD ranking by TPE is:

1. Foul-Release Coatings
2. Establish Maximum Allowable Copper Release Rate Standard for Antifouling Coatings
3. Advanced Antifouling Coatings

For the Aluminum Hulls vessel group, MPCD ranking by TPE is:

1. Foul-Release Coatings
2. Baseline Discharge
3. Advanced Antifouling Coatings

For the Flexible Hulls vessel group, the MPCD to Establish Maximum Allowable Copper Release Rate Standard for Antifouling Coatings is the only feasible option.

5.1.6 Other Potential Environmental Impacts

For the Hull Coating Leachate discharge, other environment impacts are estimated for the release of VOCs and solid waste generated resulting from coating applications.

For the Steel, Composite, and Other Non-Aluminum vessel group, copper ablative coatings have an estimated 12-year service life on the USS NIMITZ class vessel. During that same time period, foul-release coatings with a three-year service life are estimated to require three additional reapplications resulting in 1,300 pounds of VOCs released and 3.4×10^5 pounds. of solid waste generated for a USS NIMITZ class vessel on an annual basis. Currently approved, advanced antifouling coatings with a maximum two-year service life would require five additional reapplications when compared to copper ablative coatings on a USS NIMITZ class vessel. The hypothetical additional applications[2] may result in approximately 5,800 pounds of VOCs released and 5.6×10^5 pounds solid waste generated for a USS NIMITZ class vessel on an annual basis. The MPCD ranking is:

1. Establish Maximum Allowable Copper Release Rate Standard for Antifouling Coatings
2. Foul-Release Coatings
3. Advanced Antifouling Coatings

For the Flexible Hulls vessel group, copper ablative coatings have an estimated service life that is similar to foul-release coatings. Foul-release coatings release fewer VOCs per application than copper ablative coatings. Thus, foul-release coatings result in the reduction of 400 pounds of VOCs released for a USS LOS ANGELES class vessel on an annual basis. The maximum service life for advanced antifouling coatings is two years. Over a six-year period, one

[2] The applications are hypothetical because *E Paint SN-1* is not approved for use on any Navy vessel.

additional application of advanced antifouling coatings would be required when compared to copper ablative coatings. The additional coating application results in 480 pounds of VOCs released and $3.0x10^4$ pounds of solid waste generated for a USS LOS ANGELES class vessel on an annual basis. The MPCD ranking is:

1. Foul-Release Coatings
2. Establish Maximum Allowable Copper Release Rate Standard for Antifouling Coatings
3. Advanced Antifouling Coatings

For the Aluminum Hulls vessel group, foul-release or advanced antifouling coatings are currently used. The decision regarding which coating type to use is made by local maintenance staff based on issues such as the local rate of fouling growth, the prevalence of ice in a region, and the availability of contractors who can apply the foul-release coatings. If all aluminum hulled vessels use foul-release coatings, the new coating application schedule would reduce the quantity of VOCs released by 11 pounds, but solid waste generated would be increased by 560 pounds for a MLB 47 class vessel on an annual basis when compared to the current use. If all aluminum hulled vessels use advanced antifouling coatings, the frequency of coating application would increase, which increases the quantity of VOCs released by 1.3 pounds for a MLB 47 class vessel on an annual basis when compared to the current use. Advanced antifouling coatings do not need to be removed for every application, and therefore, the solid waste generated is reduced by 62 pounds for a MLB 47 class vessel on an annual basis when compared to the current use. The MPCD ranking is:

1. Foul-Release Coatings
2. Baseline Discharge
3. Advanced Antifouling Coatings

5.2 Conclusions

The results of the environmental effects analysis for the Hull Coating Leachate Discharge are presented in Table 5-5.

Table 5-5 Summary of EEA for Baseline and MPCD Option Discharges for the Hull Coating Leachate Discharge

<table>
<tr><th></th><th>Baseline Discharge</th><th>Maximum Copper Standard</th><th>Foul-Release Coatings</th><th>Advanced Antifouling Coatings</th></tr>
<tr><td colspan="5">Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group</td></tr>
<tr><td>Number of Constituents Exceeding Strictest WQC</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>Total Number of Exceeded WQC</td><td>Copper Ablative Coatings:
Acute: 19
Chronic: 16

Vinyl Antifouling Coatings:
Acute: 20
Chronic: 17</td><td>Copper Ablative Coatings:
Acute: 19
Chronic: 16

Vinyl Antifouling Coatings:
Acute: 20
Chronic: 17</td><td>0</td><td>0</td></tr>
<tr><td>Number of Exceeded Narrative Categories</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Discharge Hazard Index at 35 m Edge of Mixing Zone</td><td>Copper Ablative Coatings:
$7.0x10^{-3}$

Vinyl Antifouling Coatings:
$8.9x10^{-3}$</td><td>Copper Ablative Coatings:
$7.0x10^{-3}$

Vinyl Antifouling Coatings:
$8.9x10^{-3}$</td><td>0</td><td>$5.7x10^{-3}$</td></tr>
<tr><td>Potential Nonindigenous Species Release</td><td>Baseline</td><td>Same as baseline</td><td>Increased over Advanced Antifouling Coatings</td><td>Increased from baseline</td></tr>
<tr><td>Number of BCCs Identified</td><td>2</td><td>2</td><td>0</td><td>1</td></tr>
<tr><td>Discharge Mass Loading (lb/yr)</td><td>170,000</td><td>170,000</td><td>0</td><td>220,000</td></tr>
<tr><td>Discharge TPE (lb-equiv/yr)</td><td>220,000</td><td>220,000</td><td>0</td><td>450,000</td></tr>
<tr><td colspan="5">Flexible (Non-Aluminum) Hulls Vessel Group</td></tr>
<tr><td>Number of Constituents Exceeding Strictest WQC</td><td>1</td><td>1</td><td rowspan="8">NF</td><td rowspan="8">NF</td></tr>
<tr><td>Total Number of Exceeded WQC</td><td>Acute: 19
Chronic: 16</td><td>Acute: 19
Chronic: 16</td></tr>
<tr><td>Number of Exceeded Narrative Categories</td><td>0</td><td>0</td></tr>
<tr><td>Discharge Hazard Index at 35 m Edge of Mixing Zone</td><td>$7.0x10^{-3}$</td><td>$7.0x10^{-3}$</td></tr>
<tr><td>Potential Nonindigenous Species Release</td><td>Baseline</td><td>Same as baseline</td></tr>
<tr><td>Number of BCCs Identified</td><td>2</td><td>2</td></tr>
<tr><td>Discharge Mass Loading (lb/yr)</td><td>11,000</td><td>11,000</td></tr>
<tr><td>Discharge TPE (lb-equiv/yr)</td><td>14,000</td><td>14,000</td></tr>
<tr><td colspan="5">Aluminum Hulls Vessel Group</td></tr>
<tr><td>Number of Constituents Exceeding Strictest WQC</td><td>0</td><td rowspan="8">NF</td><td>0</td><td>0</td></tr>
<tr><td>Total Number of Exceeded WQC</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Number of Exceeded Narrative Categories</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Discharge Hazard Index at 35 m Edge of Mixing Zone</td><td>$5.7x10^{-3}$</td><td>0</td><td>$5.7x10^{-3}$</td></tr>
<tr><td>Potential Nonindigenous Species Release</td><td>Baseline</td><td>Increased over baseline</td><td>Decreased over baseline</td></tr>
<tr><td>Number of BCCs Identified</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>Discharge Mass Loading (lb/yr)</td><td>1,400</td><td>0</td><td>1,500</td></tr>
<tr><td>Discharge TPE (lb-equiv/yr)</td><td>3,000</td><td>0</td><td>3,300</td></tr>
</table>

NF = MPCD Option was determined to not be feasible.

For the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group, MPCD ranking by overall environmental effect is:

1. Foul-Release Coatings
2. Advanced Antifouling Coatings
3. Establish Maximum Allowable Copper Release Rate Standard for Antifouling Coatings

In summary, foul-release coatings have a discharge TPE of zero, are unlikely to result in any WQC exceedences, and contain no identified BCCs. Therefore, the use of foul-release coatings would result in the least environmental impact. While advanced antifouling coatings have a discharge TPE of 450, 000 lb-equiv/yr, the biocide is non-persistent. Additionally, advanced antifouling coatings are unlikely to result in any WQC exceedences and contain one identified BCC. The MPCD Option to Establish Maximum Allowable Copper Release Rate Standard for Antifouling Coatings has a discharge TPE of 220,000 lb-equiv/yr that is produced by persistent biocides, results in copper concentrations that are most likely to exceed WQC, and contains two BCCs. None of the MPCD options is expected to result in acute toxicity 35 m from the hull.

For the Flexible Hulls vessel group, the option to Establish Maximum Allowable Copper Release Rate Standard for Antifouling Coatings is the only feasible MPCD option for this vessel group.

For the Aluminum Hulls vessel group, MPCD ranking by overall environmental effect:

1. Foul-release Coatings
2. Baseline Discharge
3. Advanced Antifouling Coatings

In summary, foul-release coatings have a discharge TPE of zero, are unlikely to result in any WQC exceedences, and contain no identified BCCs. Therefore, the use of foul-release coatings would result in the least environmental impact. Advanced antifouling coatings have a discharge TPE of 3,300 lb-equiv/yr, and the primary biocide is non-persistent. Additionally, advanced antifouling coatings are unlikely to result in any WQC exceedences and contain one identified BCC. The baseline discharge is a combined use of the foul-release and advance antifouling coatings MPCD options, and therefore, is ranked between the two. None of the MPCD options is expected to result in acute toxicity 35 m from the hull.

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Appendix A

Endpoints for State Benchmark Narrative Water Quality Criteria Categories

SALTWATER	EEA ENDPOINT
BOD/DO	The discharge shall not depress receiving water dissolved oxygen concentration (1) by more than 10%, or (2) to a level that produces nuisance conditions.
Color	The discharge shall not (1) exceed 15 color units at EOP, and (2) exceed natural conditions or be visually noticeable in the receiving water.
Floating Materials	The discharge shall not release or create floating solids in the receiving waters.
Nutrients	The discharge shall not exceed 300 µg/L total nitrogen (nitrate + nitrite + KJN), 10.0 µg/L of ammonia nitrogen, 15 µg/L nitrate + nitrite, or 60.0 µg/L of total phosphorus at EOP
Odor	The discharge shall not (1) impart unpalatable flavor to food fish, or (2) result in offensive odors in the vicinity of the receiving water, or (3) exceed recommended Federal WQC for organoleptic effect.
Oil and Grease	The discharge shall not (1) have an EOP concentration of bulk oil and grease greater than 5 mg/L; (2) cause receiving water EOMZ concentration of bulk oil and grease greater than 15 µg/L; or (3) cause a sheen anywhere in the receiving
Pathogens	The discharge shall not cause receiving water to exceed at the EOMZ: (1) a geometric mean of 8 enterococci/100 ml or an instantaneous level of 54 enterococci/100 ml; (2) a geometric mean of 126 E. coli/100 ml or an instantaneous level of 406 E. coli/100 ml; or (3) 50 fecal coliform/100 ml by any measure or calculation. Graywater discharges shall not exceed at the EOP a geometric mean of 20 fecal coliform/100 ml for any 30-day period, with not more than 10% of the samples
Settleable Materials	The discharge shall not release settleable materials other than of local and natural origin.
Suspended Solids	The discharge shall not exceed 25-mg/L daily average or 45 mg/L daily maximum concentrations of TSS.
Taste	The discharge shall not impart unpalatable flavor to food fish, shellfish, and wildlife; or (2) exceed recommended Federal WQC for organoleptic effect.
Temperature	The discharge shall not cause the EOMZ temperature to increase >0.3°C.
Turbidity/Colloidal Matter	Turbidity of the discharge, including that caused by colloids, shall not be (1) visually noticeable in the receiving waters; (2) deposited to such an extent that it will detrimentally affect bottom or shoreline biota; and (3) produce a substantial increase in turbidity.
FRESHWATER	**EEA ENDPOINT**
Alkalinity	The discharge shall not (1) lower receiving water alkalinity below 20 mg/L; or (2) further reduce alkalinity of receiving water with an alkalinity of 20mg/L or less.
Hardness	The discharge shall not cause receiving water hardness to exceed 100 mg/L as calcium carbonate.
Nutrients	The discharge shall not cause the receiving water phosphorus concentration to exceed 50 µg/L.
Oil and Grease	The discharge shall not cause receiving water concentrations of oil and grease (measured as HEM) to exceed 0.10 mg/L.
Pathogens	The discharge shall not cause receiving water to exceed (1) a geometric mean of 20 fecal coliform/100 ml, or (2) exceed a geometric mean of 125 *E. coli* bacteria/100 ml.
pH	The pH of the discharge shall not (1) be less than 6.5 at EOP, (2) be greater than 9.0 at EOP, and (3) cause a receiving water change of greater than 0.5 units in pH at EOMZ.
Specific Conductance	The discharge shall not raise EOMZ conductivity of receiving water above 1000 microhms/cm.
Total Dissolved Solids	The discharge shall not cause receiving water concentration of total dissolved solids to exceed 400 mg/L.

Appendix B

VOC Release and Solid Waste Generation Calculations

Initial Background Calculations

Sources of Data:

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Material Safety Data Sheet for International 4050 Red MIL-P-15931F Form 121A (Formula 121). 19 January 2002.

Material Safety Data Sheet for International Intersleek 425 Finish Gray. 19 January 2002.

E Paint, 2002. Material Safety Data Sheet for E Paint Company *E Paint SN-1.* 22 February 2002.

Underwater Hull Environmental Emissions

Epoxy – Bar Rust 236 VOC

Practical Coverage = 83.6 ft.^{2}/gallon @ 10 mils DFT
Gallons per 100 ft.^{2} = 100/83.6 = 1.2 gallons
VOC emitted per 100 ft.^{2} = 1.2 gallons X 2.4 pounds VOC /gallon = 2.87 pounds

ABC #3 Antifouling - VOC
Practical coverage = 64.5 ft.^{2}/gallon @ 10 mils DFT
Gallons per 100 ft.^{2} = 100/64.5 = 1.55 gallons
VOC emitted per 100 ft.^{2} = 1.55 gallons X 3.3 pounds VOC/gallon = 5.12 pounds

Note: drydocking intervals of 10-12 years require 15 mils of antifoulant vice 10 mils.
15 mil thickness, =>7.68 pounds VOC per 100 ft^2

BRA640 Antifouling - VOC
Practical coverage = 74.6 ft.^{2}/gallon @ 10 mils DFT
Gallons per 100 ft.^{2} = 100/74.6 = 1.34 gallons
VOC emitted per 100 ft.^{2} = 1.34 gallons X 3.21 pounds VOC/gallon = 4.30 pounds

Note: drydocking intervals of 10-12 years require 15 mils of antifoulant vice 10 mils.
15 mil thickness, =>6.45 pounds VOC per 100 ft^2

Navy Vinyl Anti-Fouling [(Formulas 121 (red) and 129 (black)]
Practical coverage = 168.4 ft.^{2}/gallon @ 4 mils DFT (two 2-mil coats)
Gallons per 100 ft.^{2} = 100/168.4 = 0.59 gallons
VOC emitted per 100 ft.^{2} = 0.59 gallons X 2.83 pounds VOC per gallon = 1.68 pounds

E Paint SN-1 Antifouling - VOC
Practical coverage = 64.2 ft.^{2}/gallon @ 10.5 mils DFT
Gallons per 100 ft.^{2} = 100/64.2 = 1.56 gallons
VOC emitted per 100 ft.^{2} = 1.56 gallons X 3.3 pounds VOC/gallon = 5.41 pounds

Intersleek 381 (tie-coat) - VOC
Practical coverage = 252 $ft.^2$/gallon @ 3 mils DFT
Gallons per 100 $ft.^2$ = 100/252 = 0.397 gallons
VOC emitted per 100 $ft.^2$ = 0.397 gallons X 2.71 pounds VOC/gallon = 1.89 pounds

Intersleek 425 (top-coat) - VOC
Practical coverage = 288 $ft.^2$/gallon @ 3 mils DFT
Gallons per 100 $ft.^2$ = 100/288 = 0.348 gallons
VOC emitted per 100 $ft.^2$ = 0.348 gallons X 2.12 pounds VOC/gallon = 1.07 pounds

System Totals (pounds VOC per 100 ft^2) (system includes all required coats)

BRA640 (at 10 mils thickness):	7.17	
BRA640 (at 15 mils thickness):	9.32	
ABC #3 (at 10 mils thickness):	7.99	
ABC #3 (at 15 mils thickness):	10.6	
Navy vinyl (at 4 mils thickness):	4.6	
Intersleek:		4.68
E Paint SN-1:		8.82

ABC #3 Antifouling – Copper content
Pounds Cu/$ft.^2$ = gms/cm^2 - mil **X** $cm^2/ft.^2$ **X** pounds/grams **X** mils
= 0.0044 **X** 929 **X** 1/454 **X** 10
= 0.090 pounds per $ft.^2$
= 9 pounds per 100 $ft.^2$ @ 10 mils DFT

MIL-A-22262 Abrasive – Solid Waste Generation Rate

Minimum hardness required is 6.0 on Moh's scale

Results in the use of copper slag, Al_2O_3, coal slag, Garnet or Staurolite which generally yield a production rate of 4.2 square feet per minute.

For a six hour shift this results in the use of about 12,500 pounds of grit to blast 1500 square feet to a SSPC SP-10 surface finish (the requirement for most Navy preservation)

To normalize to 100 square feet, about 850 pounds of grit is used to blast 100 square feet. The amount of grit is the amount of solid waste generated.

Neither the grit nor the epoxy paint contain hazardous heavy metals per CA Title 17/22; the antifouling paint will contain copper per the above calculation.

Calculations for Individual Vessel Groups

Steel, Composite, and Other Non-Aluminum Rigid Hulls Category

VOC Release Rates for all Required Coats

ABC #3: 15 mil thickness - VOC emitted per $100ft^2$ = 11 pounds

BRA640: 15 mil thickness - VOC emitted per $100ft^2$ = 9.3pounds

Vinyl antifouling coatings: 2 2-mil coats - VOC emitted per $100ft^2$ = 4.6 pounds

Baseline Coating: VOC emitted per 100 ft^2 = 0.86(average of BRA640 + ABC #3) + 0.14*vinyl = 9.2 pounds

Interleek425 (Foul-Release Coating):VOC emitted per 100ft^2 = 4.7 pounds

E Paint SN-1 (Advanced Antifouling Coating): VOC emitted per 100ft^2 = 8.8

Vessel Data

Vessel Surface Area: 159,500 ft^2

Vessel Group Surface Area: 2.4x10^7 ft^2

VOC Calculations

VOCs per coating = Release Rate X Surface Area/100 ft^2

Baseline Discharge – per CVN class vessel = 1.5x10^4 lbs

Baseline Discharge – Vessel Group = 2.2.x10^6 lbs

Coatings over 12 years: 1

Baseline Discharge VOCs over 12 years - per CVN class vessel = 1.5x10^4 lbs

Baseline Discharge VOCs over 12 years - Vessel Group = 2.2.x10^6 lbs

Foul-Release Coating Discharge – per CVN class vessel = 7.5x10^3 lbs

Foul-Release Coating Discharge– Vessel Group = 1.1.x10^6 lbs

Coatings over 12 years: 4

Foul-Release Coating Discharge VOCs over 12 years - per CVN class vessel = 3.0x10^4 lbs

Foul-Release Coating Discharge VOCs over 12 years - Vessel Group =4.5x10^6 lbs

Delta - Foul-Release to Baseline Discharge VOCs over 12 years - per CVN class vessel = 1.5x10^4 lbs

Delta - Foul-Release to Baseline Discharge – annualized - per CVN class vessel = 1.3x10^3 lbs/year

Delta - Foul-Release to Baseline Discharge VOCs over 12 years - Vessel Group =2.3x10^6 lbs

Delta - Foul-Release to Baseline Discharge – annualized - Vessel Group = 1.9x10^5 lbs

Advanced Antifouling Coating Discharge – per CVN class vessel = 1.4x10^4 lbs

Advanced Antifouling Coating – Vessel Group = 2.1.x10^6 lbs

Coatings over 12 years: 6

Advanced Antifouling Coating Discharge VOCs over 12 years- per CVN class vessel = 8.4x10^4 lbs

Advanced Antifouling Coating Discharge VOCs over 12 years- Vessel Group = 1.3x10^7 lbs

Delta – Advanced Antifouling to Baseline Discharge VOCs over 12 years - per CVN class vessel = 7.0x10^4 lbs

Delta - Advanced Antifouling to Baseline Discharge – annualized - per CVN class vessel = 5.8x10^3 lbs/year

Delta - Advanced Antifouling to Baseline Discharge VOCs over 12 years - Vessel Group = 1.0x10^7 lbs

Delta - Advanced Antifouling to Baseline Discharge – annualized - Vessel Group = 8.7x10^5 lbs

Solid Waste Generated

Generation Rate = 850 lbs/ft

SW per coating = Release Rate X Surface Area/100 ft^2

Baseline Discharge – SW per CVN class vessel = $1.4x10^6$ lbs

Baseline Discharge – SW Vessel Group = $2.0x10^8$ lbs

Coatings over 12 years: 1

Baseline Discharge SW over 12 years - per CVN class vessel = $1.4x10^6$ lbs

Baseline Discharge SW over 12 years - Vessel Group = $2.0x10^8$ lbs

Foul-Release Coating Discharge – SW per CVN class vessel = $1.4x10^6$ lbs

Foul-Release Coating Discharge– SW Vessel Group = $2.0.x10^8$ lbs

Coatings over 12 years: 4

Foul-Release Coating Discharge SW over 12 years - per CVN class vessel = $5.4x10^6$ lbs

Foul-Release Coating Discharge SW over 12 years - Vessel Group =$8.2x10^8$ lbs

Delta - Foul-Release to Baseline Discharge SW over 12 years - per CVN class vessel = $4.1x10^6$ lbs

Delta - Foul-Release to Baseline Discharge – SW annualized - per CVN class vessel = $3.4x10^5$ lbs/year

Delta - Foul-Release to Baseline Discharge SW over 12 years - Vessel Group =$6.1x10^8$ lbs

Delta - Foul-Release to Baseline Discharge – SW annualized - Vessel Group = $5.1x10^7$ lbs

Advanced Antifouling Coating Discharge – SW per CVN class vessel = $1.4x10^6$ lbs

Advanced Antifouling Coating – SW Vessel Group = $2.0x10^8$ lbs

Coatings over 12 years: 6

Advanced Antifouling Coating Discharge SW over 12 years- per CVN class vessel = $8.1x10^6$ lbs

Advanced Antifouling Coating Discharge SW over 12 years- Vessel Group = $1.2x10^9$ lbs

Delta – Advanced Antifouling to Baseline Discharge SW over 12 years - per CVN class vessel = $6.8x10^6$ lbs

Delta - Advanced Antifouling to Baseline Discharge – SW annualized - per CVN class vessel = $5.6x10^5$ lbs/year

Delta - Advanced Antifouling to Baseline Discharge SW over 12 years - Vessel Group = $1.0x10^9$ lbs

Delta - Advanced Antifouling to Baseline Discharge – SW annualized - Vessel Group = $8.5x10^7$ lbs

Flexible (Non-Aluminum) Hulls Category

VOC Release Rates for all Required Coats

ABC #3: 10 mil thickness - VOC emitted per 100ft^2 = 8.0 pounds

BRA640: 10 mil thickness - VOC emitted per 100ft^2 = 7.2 pounds

Copper Ablative Baseline Coating: VOC emitted per 100 ft^2 = 7.6 pounds

Interleek425 (Foul-Release Coating):VOC emitted per 100ft^2 = 4.7 pounds

E Paint SN-1 (Advanced Antifouling Coating): VOC emitted per 100ft^2 = 8.8

Vessel Data

Vessel Surface Area: 34,765 ft^2

Vessel Group Surface Area: 2.0x10^6 ft^2

VOC Calculations

VOCs per coating = Release Rate X Surface Area/100 ft^2

Baseline Discharge – per CVN class vessel = 2.6x10^3 lbs

Baseline Discharge – Vessel Group = 1.5.x10^5 lbs

Coatings over 10 years: 4

Baseline Discharge VOCs over 10 years - per CVN class vessel = 1.1x10^4 lbs

Baseline Discharge VOCs over 10 years - Vessel Group = 6.1x10^5 lbs

Foul-Release Coating Discharge – per CVN class vessel = 1.6x10^3 lbs

Foul-Release Coating Discharge– Vessel Group = 9.4x10^4 lbs

Coatings over 10 years: 4

Foul-Release Coating Discharge VOCs over 10 years - per CVN class vessel = 6.5x10^3 lbs

Foul-Release Coating Discharge VOCs over 10 years - Vessel Group =3.7x10^5 lbs

Delta - Foul-Release to Baseline Discharge VOCs over 10 years - per CVN class vessel = -4.0x10^3 lbs

Delta - Foul-Release to Baseline Discharge – annualized - per CVN class vessel = -4.0x10^2 lbs/year

Delta - Foul-Release to Baseline Discharge VOCs over 10 years - Vessel Group =-2.3x10^5 lbs

Delta - Foul-Release to Baseline Discharge – annualized - Vessel Group = -2.3x10^4 lbs

Advanced Antifouling Coating Discharge – per CVN class vessel = 3.1x10^3 lbs

Advanced Antifouling Coating – Vessel Group = 1.8x10^5 lbs

Coatings over 10 years: 5

Advanced Antifouling Coating Discharge VOCs over 10 years- per CVN class vessel = 1.5x10^4 lbs

Advanced Antifouling Coating Discharge VOCs over 10 years- Vessel Group = 8.8x10^5 lbs

Delta – Advanced Antifouling to Baseline Discharge VOCs over 10 years - per CVN class vessel = $4.8x10^3$ lbs

Delta - Advanced Antifouling to Baseline Discharge – annualized - per CVN class vessel = $4.8x10^2$ lbs/year

Delta - Advanced Antifouling to Baseline Discharge VOCs over 10 years - Vessel Group = $2.8x10^5$ lbs

Delta - Advanced Antifouling to Baseline Discharge – annualized - Vessel Group = $2.8x10^4$ lbs

<u>Solid Waste Generated</u>

Generation Rate = 850 lbs/ft

SW per coating = Release Rate X Surface Area/100 ft^2

Baseline Discharge – SW per CVN class vessel = $3.0x10^5$ lbs

Baseline Discharge – SW Vessel Group = $1.7x10^7$ lbs

Coatings over 10 years: 4

Baseline Discharge SW over 10 years - per CVN class vessel = $1.2x10^6$ lbs

Baseline Discharge SW over 10 years - Vessel Group = $6.8x10^7$ lbs

Foul-Release Coating Discharge – SW per CVN class vessel = $3.0x10^5$ lbs

Foul-Release Coating Discharge– SW Vessel Group = $1.7x10^7$ lbs

Coatings over 10 years: 4

Foul-Release Coating Discharge SW over 10 years - per CVN class vessel = $1.2x10^6$ lbs

Foul-Release Coating Discharge SW over 10 years - Vessel Group =$6.8x10^7$ lbs

Delta - Foul-Release to Baseline Discharge SW over 10 years - per CVN class vessel = 0 lbs

Delta - Foul-Release to Baseline Discharge – SW annualized - per CVN class vessel = 0 lbs/year

Delta - Foul-Release to Baseline Discharge SW over 10 years - Vessel Group = 0 lbs

Delta - Foul-Release to Baseline Discharge – SW annualized - Vessel Group = 0 lbs

Advanced Antifouling Coating Discharge – SW per CVN class vessel = $3.0x10^5$ lbs

Advanced Antifouling Coating – SW Vessel Group = $1.7x10^7$ lbs

Coatings over 10 years: 5

Advanced Antifouling Coating Discharge SW over 10 years- per CVN class vessel = $1.5x10^6$ lbs

Advanced Antifouling Coating Discharge SW over 10 years- Vessel Group = $8.5x10^7$ lbs

Delta – Advanced Antifouling to Baseline Discharge SW over 10 years - per CVN class vessel = $3.0x10^5$ lbs

Delta - Advanced Antifouling to Baseline Discharge – SW annualized - per CVN class vessel = $3.0x10^4$ lbs/year

Delta - Advanced Antifouling to Baseline Discharge SW over 10 years - Vessel Group = $1.7x10^7$ lbs

Delta - Advanced Antifouling to Baseline Discharge – SW annualized - Vessel Group = $1.7x10^6$ lbs

Aluminum Hulls Category

VOC Release Rates for all Required Coats

Interleek425 (Foul-Release Coating):VOC emitted per 100ft^2 = 4.7 pounds

E Paint SN-1 (Advanced Antifouling Coating): VOC emitted per 100ft^2 = 8.8

Vessel Data

Vessel Surface Area: 440 ft^2

Vessel Group Surface Area: 1.0x10^5 ft^2

VOC Calculations

VOCs per coating = Release Rate X Surface Area/100 ft^2

Baseline Discharge – 90% Advanced Antifouling coating/10% Foul-Release Coating Mixture Calculations

Foul-Release Coating Discharge Contribution – per MLB class vessel = 2.1 lbs

FR Coatings over 12 years: 4

Foul-Release Coating Discharge VOCs over 12 years - per MLB class vessel = 8.4 lbs

Advanced Antifouling Coating Discharge Contribution – per MLB class vessel = 35 lbs

Adv. AF Coatings over 12 years: 6

Advanced Antifouling Coating Discharge VOCs over 12 years- per MLB class vessel = 210 lbs

Baseline Discharge VOCs over 12 years – per MLB class vessel – 218 lbs

Foul-Release Coating Discharge – per MLB class vessel = 21 lbs

Coatings over 12 years: 4

Foul-Release Coating Discharge VOCs over 12 years - per MLB class vessel = 84 lbs

Delta - Foul-Release to Baseline Discharge VOCs over 12 years - per MLB class vessel = -134 lbs

Delta - Foul-Release to Baseline Discharge – annualized - per MLB class vessel = -11 lbs/year

Advanced Antifouling Coating Discharge – per MLB class vessel = 39 lbs

Coatings over 12 years: 6

Advanced Antifouling Coating Discharge VOCs over 12 years- per MLB class vessel = 232 lbs

Delta – Advanced Antifouling to Baseline Discharge VOCs over 12 years - per MLB class vessel = 14 lbs

Delta - Advanced Antifouling to Baseline Discharge – annualized - per CVN class vessel = 1.1 lbs/year

Solid Waste Generated

Generation Rate = 850 lbs/ft

SW per coating = Release Rate X Surface Area/100 ft^2

Baseline Discharge – SW per MLB class vessel = $3.7x10^2$ lbs

Coatings over 12 years: 4 (for foul-release coatings); 2 (for advanced antifouling coatings – all applications do not require removal of existing coating)

Baseline Discharge SW over 12 years - per MLB class vessel = $8.2x10^3$ lbs

Foul-Release Coating Discharge – SW per MLB class vessel = $3.7x10^3$ lbs

Coatings over 12 years: 4

Foul-Release Coating Discharge SW over 12 years - per MLB class vessel = $1.5x10^4$ lbs

Delta - Foul-Release to Baseline Discharge SW over 12 years - per MLB class vessel = $6.7x10^3$ lbs

Delta - Foul-Release to Baseline Discharge – SW annualized - per MLB class vessel = $5.6x10^2$ lbs/year

Advanced Antifouling Coating Discharge – SW per MLB class vessel = $3.7x10^3$ lbs

Coatings over 12 years: 2 (all applications do not require removal of existing coating)

Advanced Antifouling Coating Discharge SW over 12 years- per MLB class vessel = $7.5x10^3$ lbs

Delta – Advanced Antifouling to Baseline Discharge SW over 12 years - per MLB class vessel = -720 lbs

Delta - Advanced Antifouling to Baseline Discharge – SW annualized - per MLB class vessel = -60 lbs/year